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Stärkekörner" written by Naegeli in 1874. This does not mean that there are not many interesting and important problems connected with the study of the starch grain, but the solution of these can be accomplished only at the hands of the experienced specialist engaged in research or under the direction of a master mind.

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March 27, 1915

SPECIAL ARTICLES

THE OSMOTIC PROPERTIES OF DIFFERENT KINDS OF MUSCLE

IN two recent articles¹ I have pointed out that the osmotic properties² of the smooth and striated muscle of the frog and of the clam's adductor muscle were strikingly different. Loeb suggests³ that the differences observed by me might be due to the fact that "the smooth muscle of the stomach . . . can not be obtained in as natural a condition as . . . striped muscle . . ." Still more recently, in an article published from Loeb's laboratory, v. Körösy⁴ has enlarged upon Loeb's suggestion and has described some experiments purporting to uphold it.

The reasons for thinking that the differences in the osmotic behavior of the three types of muscle mentioned above can not be due to any difference in the manner of their preparation seem to me very cogent; they have already been largely given in my articles dealing with the subject. But it has not previously been possible to give them completely or to bring them together into one place, and, in view of the suggestions of Loeb and v. Körösy, it seems worth while to do this now.

The first difficulty which one meets in com-

¹ Meigs, *The Journal of Experimental Zoology*, Vol. 13, p. 497, 1913; *The Journal of Biological Chemistry*, Vol. 17, p. 81, 1914.

² By "osmotic properties" I mean those properties of the tissues which determine the characteristic changes of weight undergone by them when immersed in various solutions.

³ Loeb, *SCIENCE*, N. S., Vol. 37, p. 430, 1913.

⁴ V. Körösy, *Zeitschrift für physiologische Chemie*, Vol. 93, pp. 171 et seq., 1914.

paring the reactions of smooth and striated muscle is that cutting across the fibers or removing the "natural surface" does not have the same effect on the two tissues. Striated muscle goes almost immediately into rigor in the neighborhood of a cut across its fibers. This condition is accompanied by acid formation,⁵ by swelling, and by the loss of irritability and of the characteristic osmotic properties of the tissue; it spreads gradually from the point of injury to other parts. Cutting across the fibers of smooth muscle causes a contraction which is soon followed by relaxation; there is no tendency toward acid formation, swelling or loss of irritability either in the neighborhood of the cut or in any other portion of the tissue. These facts, which are ignored by Loeb and v. Körösy, are very significant; they suggest at the outset, what is confirmed by all my subsequent work, that the fibers of striated muscle are surrounded by characteristic semi-permeable surfaces, injury to which produces profound changes in the tissue; and that no such surfaces exist in the case of smooth muscle. They are incompatible with the view that the osmotic properties of the tissues are alike. Finally, they show that my preparations of smooth muscle, in spite of the fact that their fibers have been cut, are more nearly comparable to uninjured than to injured preparations of striated muscle.

But one need not stop here. The rigor, etc., produced in the neighborhood of a cut across the fibers of striated muscle spreads only gradually from the injured to the uninjured regions; hence, if the injured area be proportionally small, the preparation will react osmotically for the first hour or so very nearly like an uninjured muscle. If a frog's sartorius be cut across its middle, either half of the muscle will have about the same proportions of "natural surface" and "unnatural surface" as the preparations of frog's stomach muscle used in my experiments. Such a cut sartorius reacts for the first hour in all respects very much like an uninjured sartorius. The strikingly different osmotic reactions characteristic of smooth muscle showed themselves

⁵ Fletcher and Hopkins, *The Journal of Physiology*, Vol. 35, pp. 261 et seq., 1907.

in my preparations long before the end of the first hour.

Further, the effects of cutting across the fibers or of exposing an "unnatural surface" in smooth muscle may be studied experimentally by comparing the reactions of preparations which have been cut in many places with those of others which have been cut as little as possible. Such experiments show that cutting has no perceptible effect after the first few minutes; for the first few minutes it produces a very slight tendency for the preparation to lose fluid. Examination of the differences in the osmotic reactions of smooth and striated muscle under different circumstances shows that these differences can not be explained as the result either of this or of any other conceivable effect of injury. Smooth muscle, for instance, swells more rapidly than striated muscle in Ringer's solution, but less rapidly in half-strength Ringer; it would be a very extraordinary hypothesis that these opposite differences were both the effects of injury. Still less can the swelling of smooth muscle in solutions of non-electrolytes and the peculiar changes of weight undergone by it in double-strength and half-strength Ringer solution be explained as the result of injury by any one who will take the trouble to make a careful study of these phenomena.

In order to obtain a preparation of striated muscle comparable to my preparations of smooth muscle v. Körösy pared off the surface layers of a frog's gastrocnemius with a razor and used the core which was left. This is, to say the least, a severe test. The gastrocnemius is for the most part composed of short fibers which run diagonally across it and end in the fascia covering its surface. The procedure adopted by v. Körösy would therefore give a surface largely or entirely composed of the cut ends of the muscle fibers. My preparations of stomach muscle were covered on one side by the serosa and on the other by a part of the connective tissue which lies between the muscular and mucous coats of the stomach; these two surfaces made up about nine tenths that of the whole preparation, and were certainly as "natural" as that which is left

covering a striated muscle after it is torn away from the skin and from the neighboring muscles.

V. Körösy tried only one experiment which bears on the osmotic differences between the smooth and striated muscle of the frog. He immersed his muscle core in 0.23 M saccharose solution and found that it gained weight fairly rapidly. It is to be presumed that lactic acid was being rapidly produced over the whole surface of v. Körösy's preparation,⁶ and it is not surprising, therefore, that it should gain weight in either 0.23 M saccharose solution or in any other solution nearly isosmotic with frog's blood. But, in view of the considerations given above, it can hardly be supposed that this experiment shows that the osmotic properties of smooth and striated muscle are alike.

V. Körösy also immersed his gastrocnemius cores in various hypertonic NaCl solutions, and found that they lost weight in the early stages of their immersion.⁷ These results are to be compared with mine on the adductor muscle of the clam, which had already begun to gain weight after five minutes' immersion in a strongly hypertonic NaCl solution.⁸ My preparation was certainly not any more injured than v. Körösy's in this case, yet under comparable experimental conditions it gained weight and his lost. I do not understand, therefore, why he thinks that his experiments with the gastrocnemius core indicate that the osmotic properties of the various kinds of muscle under consideration are alike, nor do I understand his remark on page 173, which I take to mean that we need information about the changes of weight undergone by clam's muscle in the early stages of its immersion in hypertonic solutions. We already have detailed information on this point.⁹

⁶ Fletcher and Hopkins, *The Journal of Physiology*, Vol. 35, pp. 261 *et seq.*, 1907; Laquer, *Zeitschrift für physiologische Chemie*, Vol. 93, p. 69, 1914.

⁷ *Loc. cit.*, pp. 170 and 171 and Table 11.

⁸ Meigs, *The Journal of Biological Chemistry*, Vol. 17, Experiment 17, p. 97, 1914.

⁹ Meigs, *loc. cit.*, Experiments 3 and 17, pp. 95 and 97.

With regard to v. Kőrösy's supposition (pp. 172 and 173) that my preparations of frog's stomach muscle were contaminated with acid, I can only say that it is incorrect. I took particular pains to avoid contamination of the muscle with the stomach contents; the preparations were decidedly alkaline to litmus at the beginnings of the experiments and remained so for at least twenty-four hours.

It seems to me that any further attempt to show that the smooth and striated muscle of the frog and the adductor muscle of the clam are all equally subject to the "law of Avogadro-van't Hoff" should be based on experiments on all three kinds of muscle and on careful consideration of the data already at hand, rather than on experiments confined to striated muscle and backed up only by experimentally unfounded suppositions.

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ON THE TAXONOMY OF THE PROCYONIDÆ

WITHIN recent time I have, through the courtesy of the United States National Museum and the Academy of Natural Sciences of Philadelphia, enjoyed the opportunity of making a comparative study of the skeletons of the procyonine mammals of America, and that of the panda of the Old World. These researches have resulted in the production of a memoir setting forth in full complete and comparative accounts of the osteology of all these species and genera, as well as thorough studies of their several dental armatures. This memoir carries with it thirteen quarto plates, upon which are to be found eighty-seven photographic figures, giving all the skulls and many other bones of the skeletons of these procyonine species, together with the skull of *Ailurus fulgens*. In all cases the figures are given natural size.

As there is usually some little delay in the publication of memoirs of this class, I have thought best to publish here an advance abstract, setting forth some of my findings with respect to this group in the matter of

their classification. All descriptive details, as well as the large number of osteological figures of the Procyonidæ, will be available to mammalogists later on—that is, at such time as I can arrange for the publication of this work in its entirety.

As to the panda, I have said: "Judging from the characters presented on the part of its teeth; its skull, with the presence of the alisphenoid canal, and its Asiatic habitat, it is clear that *Ailurus fulgens*, the panda, is but remotely related to such forms as the raccoons, the coatis, or the kinkajous. Wherever it belongs, it does *not* belong in there. Having studied only the teeth and skull of a single individual, I am not prepared to say much in regard to its affinities; but I am of the opinion that it belongs, as a superfamily, Ailuroidæ, between the bears and the procyonine forms. Possibly *Ailuropus* may be the connecting type here—that is, with the ursine series.

Apart from their special character differences, which have been given in detail above, the dental formulæ agree in *Bassariscus*, *Nasua* and *Bassaricyon*, while in *Potos* the formula is different. This fact alone is sufficient evidence to convince a mammalogist that the Kinkajous are, at least to this extent, more or less removed from the more typical raccoon group. In *Bassaricyon*, although the formula is the same as in a raccoon, the teeth differ markedly in their special characters. Especially is this the case with respect to their morphology and extremely feeble tuberculation.

In not a few particulars its cranium and mandible agree with that part of the skeleton in *Bassariscus*, though the curvature of the superior cranial line is more as we find it in *Procyon*—that is, in *Bassaricyon* it is not so flat and straight as it is in the ring-tailed *bassar*is.

Not having examined the entire skeleton, my opinion is given tentatively in so far as the taxonomical position of *Bassaricyon* is concerned; but with the morphology of its teeth and skull before us, it is clear that it possesses characters common to both the true